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Title : TRADING SYSTEM WITH ELFS AND UMPIRES

TRADING SYSTEM WITH ELFS AND UMPIRES

BACKGROUND OF THE INVENTION

The present invention relates to securities trading systems, and more particularly, is directed to a system for facilitating price improvement from a crowd of programs respectively representing orders.

Shares representing corporate securities and other fungible financial instruments are typically bought and sold between parties via a trading process in which the owner (seller) informs his or her broker that the owner is interested in selling shares, and the would-be owner (buyer) informs his or her broker that the would-be owner is interested in buying shares.

In the simplest cases, the owner tells the broker to sell a specified number of shares immediately at whatever price can be obtained; this is referred to as a "market" order. In a more sophisticated case, the owner tells the broker to sell according to certain predetermined terms and conditions. For example, the owner may specify the sale price, referred to as a limit price, and the order then being referred to as a "limit" order. The owner may also specify other terms, such as "all or none", "fill or kill" and/or the contra-parties that the owner is willing to sell to. The buyer is able to give corresponding instructions to his or her broker.

Conventional centralized order matching systems are well suited for this type of order matching. Indeed, some large brokerage firms have sufficient order flow to match buy and sell orders in their own systems, without sending the order to a centralized system. For small orders, as measured by a suitable combination of number of shares and total value in dollars or other currency, the conventional order matching systems are cost-effective and are used to execute a large percentage of orders.

1 Conventional order matching systems are not used by the brokerage community for the
2 overwhelming majority of medium and large size orders, as the brokerage community insists it
3 can get better prices using human brokers, despite the larger commission costs.

4 Furthermore, in more challenging cases in the trading process, the owner advises the
5 broker of how many shares the owner might be interested in selling, if the broker can get a "good
6 price". A buyer may indicate interest in a corresponding manner. This is not an order, but rather
7 an expression of interest. Conventional order matching systems are transparent to this type of
8 market pressure. However, human brokers are able to use such information to seek contra-
9 parties, thus providing markets with more depth and liquidity.

10 It is desirable to provide an automated system in which shares may be traded with the
11 flexibility present when human brokers are involved in the trade.

12 There are many marketplaces for trading financial instruments. In each of these
13 marketplaces, to trade a new type of security, for example, futures on the outcome of a political
14 election, or shares in the revenue produced by a football team, requires a costly set-up process
15 wherein potential traders are apprised of the existence of the new instrument and its trading rules.

16 It is desirable to provide an automated system for trading new financial instruments, or
17 for trading existing instruments according to a new procedure, that avoids the costly set-up
18 process.

19 SUMMARY OF THE INVENTION

20 In accordance with an aspect of this invention, there is provided a method of setting a
21 price for a security, comprising maintaining an order book including orders to buy or sell
22 specified quantities of the security at respective prices, the lowest sell order price of the booked
23 orders being the book sell price, the highest buy order price of the booked orders being the book

1 buy order price, automatically engaging in a price discovery procedure before responding to a
2 request for a current buy or sell price of the security to produce an automatically discovered
3 price, and providing the automatically discovered price as the current buy or sell price, the
4 automatically discovered price being better than the book buy or sell price.

5 In some cases, the price discovery procedure includes providing the book buy or sell
6 price to at least one entity registered to participate in the price discovery procedure. The entity
7 automatically provides an improved price relative to the book price based on a predetermined
8 strategy that is determined independently of the strategies for other entities. The temporal
9 duration of the price discovery procedure can be predetermined or based on an amount of
10 activity occurring during the price discovery procedure.

11 In accordance with a further aspect of this invention, there is provided a method of
12 providing a published price for a security. A set of entities is notified of a proposed price for
13 buying or selling a pending number of shares of a security. The method automatically
14 determines whether any of the entities has offered an improved price, and provides the improved
15 price as the published price.

16 In some cases, when there is no improved price, the proposed price is provided as the
17 published price. A decision is made to offer a proposed price when a current book price is
18 different than a most recent trade price.

19 In accordance with another aspect of this invention, there is provided a method of
20 participating in pricing of a security, comprising receiving a proposed price for a pending
21 number of shares of the security, automatically determining whether to improve upon the
22 proposed price, and when the determination is affirmative, offering an improved price.

1 It is not intended that the invention be summarized here in its entirety. Rather, further
2 features, aspects and advantages of the invention are set forth in or are apparent from the
3 following description and drawings.

4 5 BRIEF DESCRIPTION OF THE DRAWINGS

6 Fig. 1 is a block diagram illustrating ELF programs and an umpire program;
7 Fig. 2 is a flowchart depicting operation of an ELF program;
8 Fig. 3 is a flowchart depicting operation of an umpire program;
9 Fig. 4 is a diagram showing how Figs. 4A and 4B are to be read together; and
10 Figs. 4A and 4B are a chart illustrating an example of operation of ELF programs and an
11 umpire program.

12 13 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

14 A centralized order processing system includes two types of software programs that
15 interact in real-time: ELF programs and umpire programs. An extended liquidity finder (ELF)
16 program is created by a broker to represent his or her orders. An umpire program is created by a
17 party to provide a service to ELF programs. For example, a trading umpire program may
18 provide an electronic exchange to supervise interaction between ELF programs; a pricing umpire
19 program may, in response to a request from an ELF program, provide a price for a security
20 according to a proprietary pricing strategy; a regulatory umpire program may provide
21 surveillance functions to an electronic marketplace, such as authorizing an order match for
22 conversion into a trade; and so on.

1 Because each order is represented by a program, rather than merely by specified terms
2 and conditions, substantial additional flexibility is provided relative to conventional order
3 processing systems. The ELF program includes code for providing defined behavior and/or the
4 ability to communicate with the broker that is represented by the ELF program. The strategy
5 followed by an ELF program may be maintained fully or partially confidential, or fully or
6 partially public, as determined by the broker that programs the ELF program.

7 Because the structure of the present system is available to each new umpire program, the
8 set-up process for trading new financial instruments, or for trading existing instruments
9 according to a new procedure, costs less than in conventional marketplaces.

10 An embodiment of the present trading system will now be described with reference to
11 Figs. 1-3, and an exemplary operation of this embodiment will be described with reference to
12 Fig. 4.

13 Fig. 1 shows centralized trading system 5 in communication with computers 20-24 in the
14 order rooms of respective brokers. Each of computers 20-24 is associated with a respective ELF
15 program 10-14 via a communication channel such as a dedicated telephone line, a dial-up
16 telephone line, a computer network, a wireless connection or other appropriate channel. Umpire
17 program 30 is a trading umpire and has an associated order book stored in storage 31.

18 Regulatory umpire program 21 and theoretical price umpire program

19 Centralized trading system 5 comprises one or more general purpose computers
20 programmed to execute ELF programs 10-14 and umpire programs 30, 32 and 33 and storing
21 associated data.

Fig. 2 is a flowchart illustrating actions that ELF programs 10-14 perform. In a set-up phase, discussed below, parameters and specific code for ELF programs 10-14 are provided and possibly published by the parties responsible for the ELF programs.

During operation, at step 105, ELF program 10 registers with umpire program 30 to indicate that ELF program 10 is active. At step 110, ELF program 10 requests a price from umpire program 30. Each umpire program provides a price according to its own published procedures, discussed below.

At step 115, ELF program 10 decides whether it will take the price from umpire program 30 and form a match with an order it is representing. Step 115 is shown with a bold outline, indicating that processing occurs according to a customized strategy defined by the broker that is responsible for ELF program 10. If ELF program 10 wishes to form a match at the quoted price, then at step 120, umpire program 30 takes appropriate action to convert the matched orders into a trade, as discussed below, and if ELF program 10 wishes to find another match, processing returns to step 110, wherein ELF program 10 requests a current price from umpire program 30. If ELF program 10 does not wish to find more matches, then processing proceeds to step 160, wherein ELF program 10 deregisters with umpire program 30, and processing is completed.

If, at step 115, ELF program 10 decided not to form a match at the price from umpire program 30, then processing proceeds to step 125, wherein ELF program 10 decides whether to submit all or part of its order to umpire program 30 for placement in the order book of umpire program 30. Step 125 is shown with a bold outline, indicating that processing occurs according to a customized strategy defined by the broker that is responsible for ELF program 10. If the entire order is left with umpire program 30, then processing proceeds to step 170, wherein ELF program 10 deregisters with umpire program 30, and processing is completed.

If, at step 125, ELF program 10 decided to continue representing at least part of its order, then at step 130, ELF program 10 “joins the crowd” at umpire program 30, that is, it remains registered at umpire program 30 and available for activity notification from umpire program 30. It will be appreciated that ELF program 10 may be simultaneously registered at multiple umpires, corresponding to representing its order in multiple markets, but this example is concerned with only umpire program 30.

At step 135, an activity notification occurs, specifically, umpire program 30 notifies ELF program 10 that, in response to a price request from another ELF program, umpire program 30 is about to change its price to a new price in accordance with the published price movement strategy of umpire program 30.

At step 140, ELF program 10 decides whether it wishes to improve upon the new price proposed by umpire program 30. Step 140 is shown with a bold outline, indicating that processing occurs according to a customized strategy defined by the broker that is responsible for ELF program 10. If not, then processing returns to step 130 and ELF program 10 continues to be in the crowd for umpire program 30.

If, at step 140, ELF program 10 decided that it should provide an improved price, then at step 145, ELF program 10 offers a better price to umpire program 30. As discussed below, umpire program 30 receives this price, possibly along with other prices from other ELF programs in its crowd, and eventually provides a price to the requesting ELF program.

At step 150, ELF program 10 determines whether the price provided by ELF program 10 has resulted in an order match using the published strategy of umpire program 30. If not, then processing returns to step 125.

1 If it is determined at step 150 that the improved price from ELF program 10 resulted in
2 an order match, then at step 155, ELF program 10 determines whether it has any more share
3 volume remaining in its original order. If not, then processing proceeds to step 160. If so, then
4 processing returns to step 130.

5 It will be seen that the benefit of putting an order in the book of umpire program 30 is
6 that when the price changes, the booked orders have execution priority. However, the benefit of
7 not putting an order in the book of umpire program 30 is that the existence and size of the order
8 remains secret.

9 The strategy of an ELF program may depend on one or more of the following factors:

- 10
- the size of the crowd at umpire program 30 and/or who is in the crowd, if an ELF
11 program chooses to identify its responsible broker,
 - previous prices,
 - a theoretical price from theoretical price umpire 33,
 - what is in the book, to the extent that an umpire reveals its book,

12
13
14
15 and so on.

16 Fig. 3 is a flowchart illustrating actions that trading umpire program 30 performs. In a
17 set-up phase, discussed below, parameters and specific code for umpire program 30 are provided
18 and possibly published by the party responsible for the umpire program.

19 Umpire program 30 simultaneously performs two types of functions: maintaining its
20 order book, and managing the crowd of ELF programs registered therewith. Umpire program 30
21 may be configured as a multi-threaded program, with one thread for its book processing and a
22 separate thread for each ELF program registered therewith. Other suitable programming
23 structures will be apparent to those of ordinary skill.

1 Maintaining the order book will now be discussed.

2 At step 205, umpire program 30 receives an order for its order book from an ELF
3 program. At step 210, umpire program 30 determines whether this order can be matched with
4 any other orders in the book according to a strategy published by the creator of umpire program
5 30. If a match cannot be formed, then at step 215, the received order is stored in the order book.
6 If a match can be formed, then at step 225, umpire program 30 takes appropriate action to report
7 the trade. Another aspect of book management is removing order from the book as they are
8 matched with orders from the crowd; this is not shown, and is well understood to those of
9 ordinary skill in the art.

10 Managing the crowd of registered ELF programs will now be discussed.

11 At step 235, umpire program 30 receives a registration from ELF program 10. At step
12 240, ELF program 10 inquires what the current price is. Umpire program 30 responds to a price
13 request according to its published strategy. For this example, the price provision procedure is as
14 shown in steps 245-265, indicated by a dashed line in Fig. 3 and discussed below, but other
15 strategies may be used.

16 At step 270, umpire program 30 determines whether there is a match, that is, whether
17 ELF program 10 has taken at least one price provided by umpire program 30. If there is no
18 match, that is, ELF program 10 has not taken the offered price, then processing proceeds to step
19 275, wherein ELF program 10 joins the crowd” at umpire program 30, that is, it remains
20 registered at umpire program 30 and available for activity notification from umpire program 30.
21 Umpire program 30 keeps ELF program 10 in its crowd until, at step 285, umpire program 30
22 receives a deregistration notice from ELF program 10, at which point processing for ELF
23 PROGRAM 10 is completed. It will be appreciated that, at any time while ELF program 10 is in

1 the crowd for umpire program 30, ELF program 10 may book an order with umpire program 30.

2 A booked order may be all or part of the order represented by ELF program 10.

3 If at step 270, umpire program 30 determines that a match has been formed, then at step
4 280, umpire program 30 takes appropriate action to report the trade, and processing proceeds to
5 step 275.

6 The price provision procedure for umpire program 30 will now be discussed.

7 During set-up of umpire program 30, its price provision procedure is selected and
8 published by the creator of umpire program 30. During set-up of the ELF programs, the price
9 provision strategy of the umpires they interact with is obtained. Accordingly, an ELF program
10 asking an umpire program for a price understands the nature of the information being provided
11 by the umpire program, and ELF programs in the crowd of an umpire program can properly
12 participate in price setting.

13 At step 245, umpire program 30 has received the price request that ELF program 10
14 issued at step 240. Umpire program 30 first determines whether the available price based on its
15 booked orders is the same as the price at which the most recent match occurred. If so, then at
16 step 265, umpire program 30 provides a price to ELF program 10 based on its book. In some
17 embodiments, umpire program 30 may provide a list of all or part of the booked orders, or a
18 summary showing booked share volume at each price or at prices near the available price.

19 However, if at step 245, umpire program 30 determines that the available price based on
20 its booked orders is the different than the price at which the most recent match occurred, then at
21 step 250, umpire program 30 notifies its crowd of ELF programs of what its proposed new price
22 will be. At step 255, umpire program 30 determines whether any of the ELF programs in its
23 crowd are willing to provide a better price. In some cases, multiple ELF programs may be

1 willing to provide a better price, and so umpire program 30 selects one of the ELF programs
2 based on its published price provision strategy. If none of the ELF programs in its crowd are
3 willing to provide a better price, then processing proceeds to step 265, and the proposed price
4 based on the booked orders is provided.

5 However, if at step 255, umpire program 30 determines that a better price is available
6 from its crowd of ELF programs, then at step 260, umpire program 30 provides the price from
7 the ELF program in the crowd to ELF program 10.

8 It will be appreciated that different ELF programs can readily use different strategies to
9 provide price improvement to expeditiously execute their own orders. The ELF programs can
10 make more informed decisions than brokers in a crowd, because the ELF programs can be in
11 real-time communication with many data sources, both present in the marketplace of trading
12 system 5 and external to trading system 5. Alternatively, an ELF program may merely present
13 its universe of information to a remote trader; the remote trader can be electronically "present" in
14 many markets simultaneously.

15 An example of a set-up phase for ELF programs 10 and 13, and umpire program 30 will
16 now be provided. It will be appreciated that a wide variety of strategies may be used. When a
17 broker wishes to try several markets for the same order, the broker is responsible for ensuring co-
18 ordination of ELF programs to avoid multiple executions of the same order.

19 During a set-up phase, the owners of the ELF and umpire programs decide

- 20 • the program's strategy,
- 21 • how much of the strategy will be public
- 22 • for an ELF program, the umpire program(s) it may register at, and who is (or is
- 23 not) an acceptable trading partner, and

- for an umpire program, the ELF programs that are (or are not) acceptable.

As shown in Fig. 1, ELF programs 10, 11, 13 and 14 are approved for registration at umpire program 30, but ELF program 12 is not allowed to register at umpire program 30. Let it be assumed that all ELF programs are willing to trade with each other.

In this example, umpire program 30 is a book umpire, meaning it maintains a file (book) of orders left by ELF programs for execution by the umpire program. It will be appreciated that a special ELF program may be used to represent an external market to increase the market depth. The price provision strategy of umpire program 30 is to give all registered ELF programs a copy of the book when they register; and in response to a request, to provide a firm price quote within one second. Partial matches at the quote are allowed. More specifically, if the book price is the same as the last match price, then umpire program 30 provides the book price as its quote.

However, if the best book price is different than the last match price, then umpire program 30 notifies its crowd that it is about to offer a changed price, and will take the first improved price provided within one second. Additionally, umpire program 30 does not allow an ELF program to “walk the book”, instead, umpire program 30 requires clean-up pricing, described in detail below.

In this example, ELF program 10 is assumed to represent an order to BUY 100,000 shares of the security being traded at umpire program 30.

- ELF program 10 will not take the first price offered by umpire program 30; this is an “I can get you a better price” strategy.
- ELF program 10 will initially book 5,000 shares at two whole points below the quote, and will book when less than 10,000 of its shares are unmatched at a price of 0.5 points below its last execution.

- The price improvement strategy of ELF program 10 is: (i) when the umpire's proposed price is at least 0.3 different than the last execution price, offer a price that is 0.1 better than the proposed price; or, (ii) if ELF program 10 offered an improved price in the last match, and can offer that price again as an improvement, then do so.

In this example, ELF program 13 is assumed to represent an order to SELL 50,000 shares of the security being traded at umpire program 30.

- ELF program 13 will take the first price offered by umpire program 30, and until its order is matched, will take the next two prices offered by umpire program 30, then pause and wait for new instructions from computer 23; this is a "hurry and sell" strategy.
- ELF program 13 will never book any of its shares.
- The price improvement strategy of ELF program 13 is: do not improve the price.

Fig. 4 is a diagram depicting how Figs. 4A and 4B are to be read together. Figs. 4A and 4B are henceforth referred to as Fig. 4.

At time 300, the book is as shown in Fig. 4. Let it be assumed that the previous match was a match at a price of 17.

At time 302, ELF program 10 establishes communication with umpire program 30. At time 304, ELF program 10 registers with umpire program 30 as a buyer. At time 306, ELF program 10 requests a price quote. Umpire program 30 determines that its last match price (17) is different than the sell price of the book (18), then determines that no one else is in the crowd, so at time 308, umpire program 30 provides the book price as its quote:

sell 400 @ 18

At time 310, ELF program 10 declines the price quote according to its strategy, and books 5000 shares at two points below the quote, that is, at a price of 16. Accordingly, at time 312, the book is as shown, specifically, the order volume at 16 has increased by 5000 shares.

The steps of the flowcharts of Figs. 2 and 3 executed during the above-described actions are shown in Table 1.

TABLE 1

	ELF 10	umpire 30	ELF 13
time 304	step 105	step 235	
time 306	step 110	step 240	
time 308	step 110	step 265	
time 310	step 125	step 205	
time 312	step 130	step 215	

At time 314, ELF program 13 establishes communication with umpire program 30. At time 315, ELF program 13 registers with umpire program 30 as a seller. At time 318, ELF program 13 requests a price quote. Umpire program 30 determines that its last match price (17) is the same as the buy price of the book, so at time 320, umpire program 30 provides the book price as its quote:

buy 2000 @ 17

Following its strategy, at time 322, ELF program 13 takes this price, thereby forming a match. Accordingly, at time 324, the book is as shown, specifically, the order volume at 17 is gone.

The steps of the flowcharts of Figs. 2 and 3 executed during the above-described actions are shown in Table 2.

TABLE 2

	ELF 10	umpire 30	ELF 13
time 316		step 235	step 105
time 318		step 240	step 110
time 320		step 265	step 110
time 322		step 280	step 115

At time 326, ELF program 13 requests a price quote. Umpire program 30 determines that its last match price (17) is different than the new buy price of the book (16.8), and at time 328, notifies the crowd, that is, ELF program 10, of its proposed new price. Following its strategy of being silent when the proposed price is less than 0.3 points different than the previous price, ELF program 10 does not offer its own price. So at time 330, umpire program 30 provides the book price as its quote:

buy 400 @ 16.8

Following its strategy, at time 332, ELF program 13 takes this price, thereby forming a match. Accordingly, at time 334, the book is as shown, specifically, the order volume at 16.8 is gone.

The steps of the flowcharts of Figs. 2 and 3 executed during the above-described actions are shown in Table 3.

TABLE 3

	ELF 10	umpire 30	ELF 13
time 326		step 240	step 110
time 328	step 135	step 250	step 110
time 330		step 265	step 110
time 332		step 280	step 115

At time 336, ELF program 13 requests a price quote. Umpire program 30 determines that its last match price (16.8) is different than the new buy price of the book (16.4), and at time 338, notifies the crowd, that is, ELF program 10, of its proposed new price and volume. Following its strategy of improving the price when the proposed price is at least 0.3 points different than the previous price, at time 340, ELF program 10 offers its own price of 16.5. So at time 342, umpire program 30 provides the price from ELF program 10 as its quote:

buy 21,000 @ 16.5

Following its strategy, at time 344, ELF program 13 takes this price, thereby forming a match.

The steps of the flowcharts of Figs. 2 and 3 executed during the above-described actions are shown in Table 4.

TABLE 4

	ELF 10	umpire 30	ELF 13
time 336		step 240	step 110
time 338	step 135	step 250	step 110
time 340	step 140	step 255	step 110
time 342		step 260	step 110
time 344		step 280	step 115

At time 346, ELF program 13 requests a price quote. Umpire program 30 determines that its last match price (16.5) is different than the new buy price of the book (16.4), and at time 338, notifies the crowd, that is, ELF program 10, of its proposed new price and volume. Following its strategy of improving the proposed price at its last match price, at time 350, ELF program 10 offers its own price of 16.5. So at time 352, umpire program 30 provides the price from ELF program 10 as its quote:

buy 21,000 @ 16.5

Following its strategy, at time 354, ELF program 13 takes this price, thereby forming a match.

The steps of the flowcharts of Figs. 2 and 3 executed during the above-described actions are shown in Table 5.

TABLE 5

	ELF 10	umpire 30	ELF 13
time 346		step 240	step 110
time 348	step 135	step 250	step 110
time 350	step 140	step 255	step 110
time 352		step 260	step 110
time 354		step 280	step 115

At time 356, ELF program 13 requests a price quote. Umpire program 30 determines that its last match price (16.5) is different than the new buy price of the book (16.4), and at time 358, notifies the crowd, that is, ELF program 10, of its proposed new price and volume. Following its strategy of improving the proposed price at its last match price, at time 360, ELF program 10 offers its own price of 16.5. So at time 362, umpire program 30 provides the price from ELF program 10 as its quote:

buy 21,000 @ 16.5

Following its strategy, at time 354, ELF program 13 takes this price for its remaining 5,600 shares, thereby forming a match. ELF program 13 has now sold all of the shares in its order, so at time 366, ELF program 13 deregisters as a seller in the crowd for umpire program 30.

The steps of the flowcharts of Figs. 2 and 3 executed during the above-described actions are shown in Table 6.

TABLE 6

	ELF 10	umpire 30	ELF 13
time 356		step 240	step 110
time 358	step 135	step 250	step 110
time 360	step 140	step 255	step 110
time 362		step 260	step 110
time 364		step 280	step 115
time 366		step 285	step 160

As illustrated by the price improvement strategy of ELF program 10, an ELF program's strategy can be a series of rules or conditions that collectively operate in pachinko fashion (a Japanese game wherein a ball is rolled down a board until it finds a hole of the proper size to go into).

The price improvement achieved in the example of Fig. 4 will now be quantified.

When ELF program 10 arrived at umpire program 30, the book was as shown at time 300. To match its BUY 100,000 share order, ELF Program 10 would have taken shares at prices from 18 through 19. Taking each of the booked orders at its limit price ("walking the book") causes a price disadvantage for the sell orders at the best price (18) relative to the orders at the clean-up (furthest from market) price (19), which is contrary to the priority an order should get for being exposed to the public in the book. Accordingly, as published during set-up, umpire program 30 requires clean-up pricing, meaning that ELF program 10 would have to take the clean-up price for all of its shares, to prevent disadvantage to the order booked at the best price. Thus, the book price for ELF program 10's entire order would have been 19. As seen from the example in Fig. 4, ELF program 10 has so far bought 47,000 shares at 16.5, which is a dramatically better price than 19.

When ELF program 13 arrived at umpire program 30, the book was as shown at time 312. To match its SELL 50,000 share order, ELF program 13 would have taken shares at prices from 17 through 15.9. Since umpire program 30 requires clean-up pricing, the book price for ELF program 13's entire order would have been 15.9. As can be seen from the example in Fig. 4, ELF program 13 sold at an average price of:

$$\frac{(2,000)(17) + (400)(16.8) + (47,600)(16.5)}{50,000} = 16.5224$$

As can be seen, ELF program 13 obtained an improved price of 16.5224 relative to the book price of 15.9.

Although an illustrative embodiment of the present invention, and various modifications thereof, have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to this precise embodiment and the described modifications, and that various changes and further modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.